Terra & Aqua - CRS Edition 2B - FSW Edition 2C
Surface and Atmosphere Radiation Budget (SARB)

Corrections to slides 8, 21, and 22 made on 9 May 2005

Clouds and the Earth's Radiant Energy System (CERES)
Science Team Meeting (3-5 May 2005)
at Geophysical Fluid Dynamics Laboratory (GFDL), New Jersey

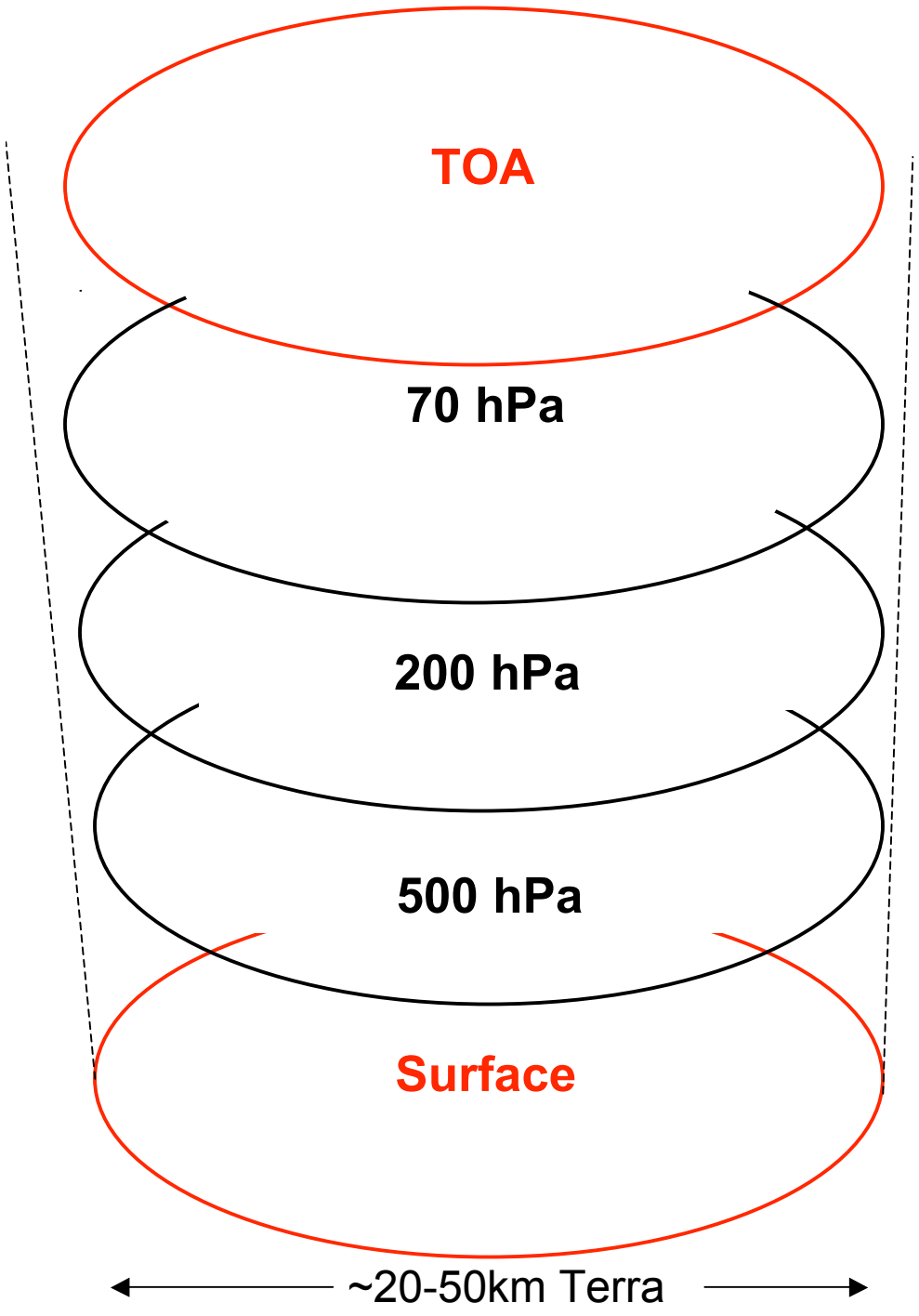
The Gang of Four:

T. P. Charlock (NASA LaRC)
Fred G. Rose (AS&M) - display of on line Fu-Liou broadband code
David A. Rutan (AS&M) - CAVE
Zhonghai Jin (AS&M) - Co-I talk on Thursday (snow trouble),
but GCM'ers should get his ocean surface albedo **today**.

Sent to CAVE for rendition:

Lisa H. Coleman, Thomas E. Caldwell, Scott Zentz (SAIC) - Data Management
Seiji Kato (H.U.) - fellow traveler in ADM group
David Fillmore and Bill Collins (NCAR) - MATCH
Wenying Su (H.U.) - surface UV and PAR algorithms

www-cave.larc.nasa.gov/cave/ or goggle "CERES CAVE"



CERES CRS: Surface and Atmosphere Radiation Budget (SARB) Product

Tuned fluxes at all 5 levels
All-sky & Clear-sky, Up & Down,
SW and LW

Surface & TOA also have Untuned fluxes
Fluxes with aerosols
Pristine fluxes (no aerosols)

Aerosol forcing for all-sky & clear-sky

Tuning does NOT yield a perfect match to TOA observations.

Parameters adjusted when clear:
Skin temperature, aerosol AOT, precipitable water (PW)

Parameters adjusted when cloudy:
LWP/IWP, cloud top temperature, cloud fractional area within footprint

http://www-cave.larc.nasa.gov/cave/ "CAVE" - the ad hoc helper

NASA Langley CERES ARM Validation Experiment CAVE

Home | Surface Observations | CERES CRS Data | CERES ES8 Data | Atmospheric Profiles | Useful Links

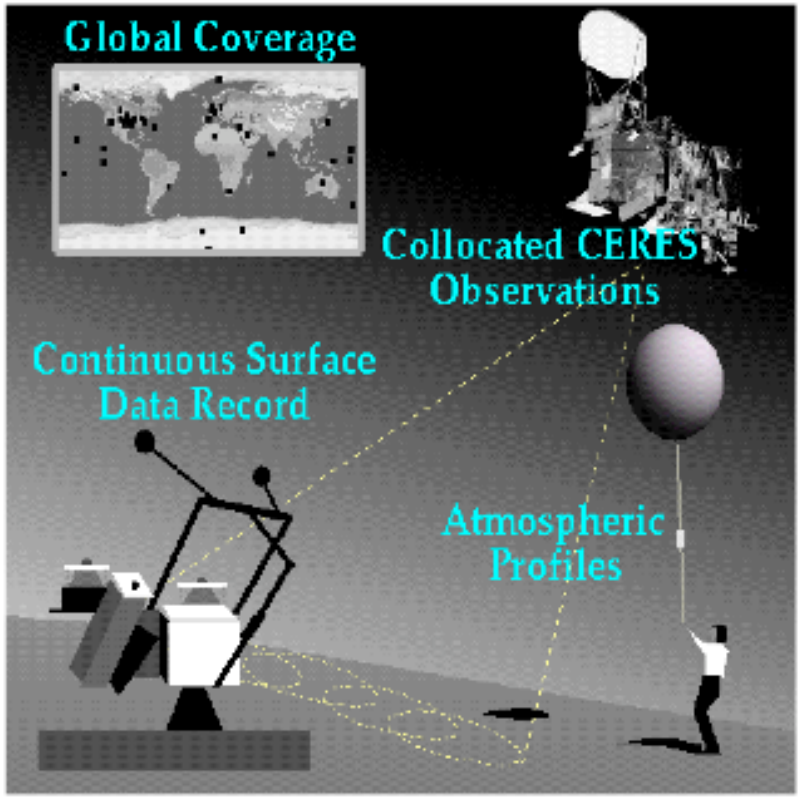
Welcome to the CAVE web site. Data collected in this effort are meant for use in validation studies of Clouds & The Earths Radiant Energy System (CERES) instruments operating on the Tropical Rainfall Measurement Mission (TRMM) and Earth Observing Systems(EOS) Terra (soon Aqua) satellites.

Important Change to CAVE Surface flux, Aerosol, Meteorology (SAM) Files

Please Read for Details

CAVE Data Info & Validation Results

- Overview and Site Map
- Plot CAVE Data On Line
- Validation Plots & Statistics
- Publications
- Cloud Fraction In CAVE
- Aerosols In CAVE
- Updates Mar 23, 2005
- The Group

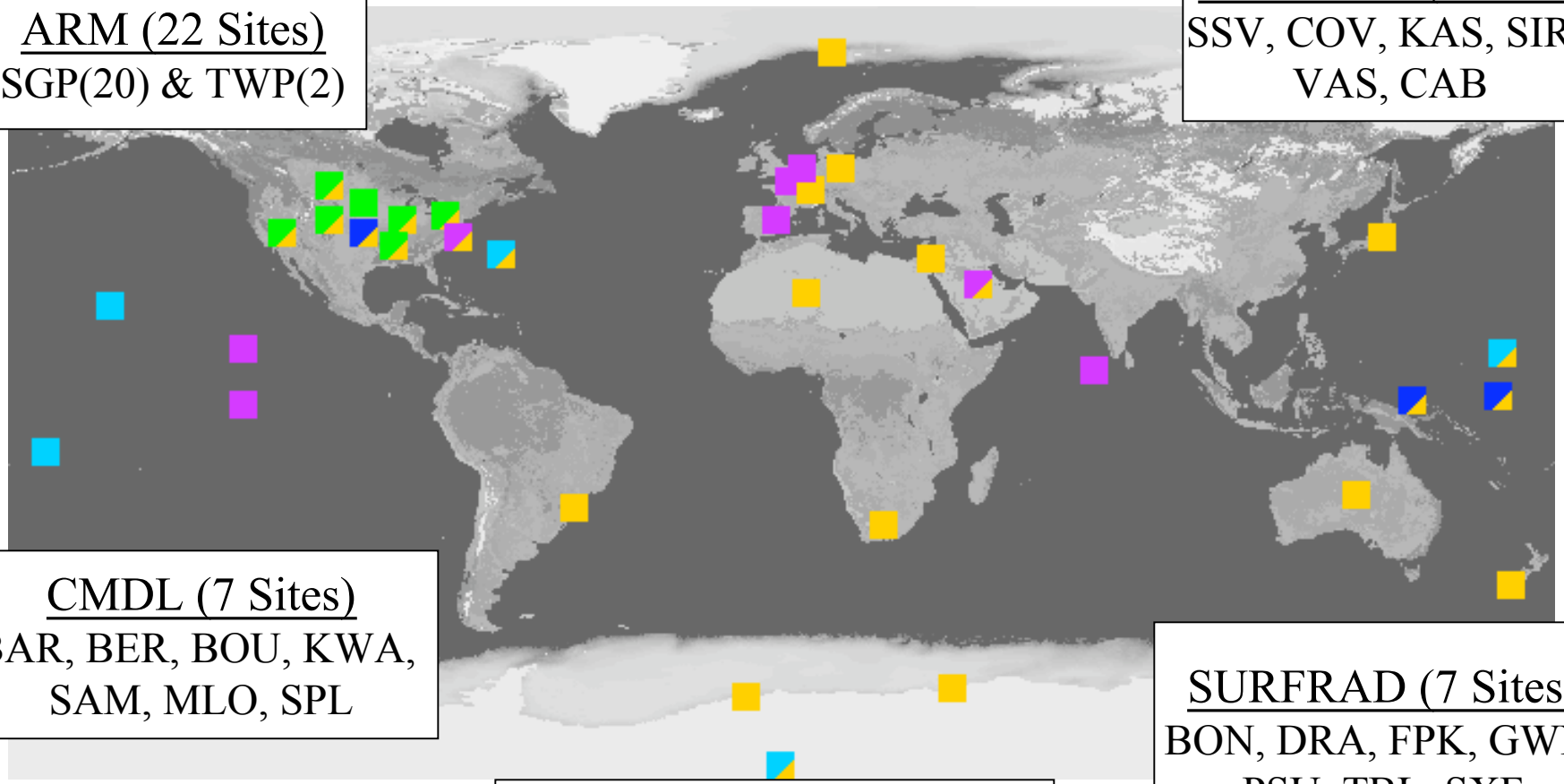


Referencing CAVE data

Radiation Transfer & Related Links

- COART Coupled Ocean-Atmos RT Model
- Ocean Albedo Look-up Table
- Point & Click Fu & Liou
- CRS Advice
- CLAMS
- ULDB Balloon Observations
- Site Map

Surface sites in CAVE surface validation program



ARM (22 Sites)
SGP(20) & TWP(2)

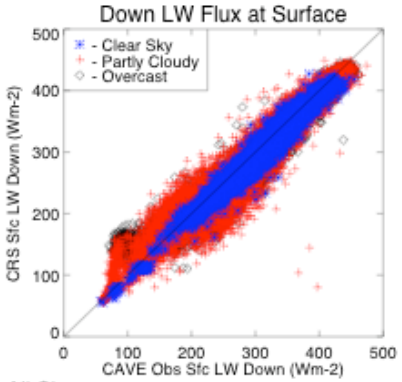
Other Sites (6 Sites)
SSV, COV, KAS, SIR, VAS, CAB

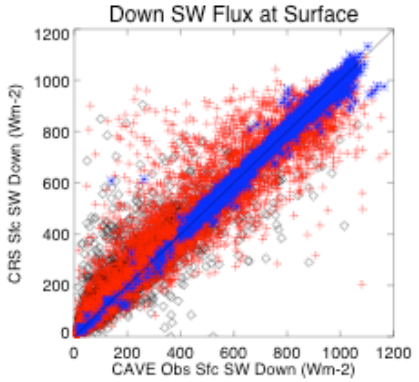
CMDL (7 Sites)
BAR, BER, BOU, KWA, SAM, MLO, SPL

SURFRAD (7 Sites)
BON, DRA, FPK, GWN, PSU, TBL, SXF

BSRN (12 Sites)
ASP, DAA, FLO, GVN, LAU, LIN, NYA, PAY, SBO, SYO, TAM, TAT

CAVE Surface Validation Untuned CRS 2001 (Ed 2B)





All Sky

	Obs Mean	N	Bias CRS-Obs	Std Dev	RMS	Mod Frc All-Clr	Forcing All-CNA
LW Dn Sfc	286.0	22420	-6.1	23.6	24.4	28.1	1.1
LW Up Sfc	353.5	10938	-3.6	25.1	25.4	--------	--------
SW Dn Sfc	444.3	11204	13.1	93.6	94.5	-113.9	-9.7
SW Up Sfc	112.8	5152	-18.4	51.2	54.4	--------	--------
LW Up TOA	218.8	22885	1.4	8.6	8.8	-20.7	-0.4
SW Up TOA	261.0	10873	10.7	26.1	28.2	80.7	3.4

Clear Sky MODIS

	Obs Mean	N	Bias CRS-Obs	Std Dev	RMS	Dif Bias CRS-Obs	AOT Frc Clr-Prs
LW Dn Sfc	291.5	3500	-8.7	14.2	16.7	--------	2.9
LW Up Sfc	400.0	2263	-0.7	20.7	20.7	--------	--------
SW Dn Sfc	726.1	1801	-0.4	30.5	30.5	--------	-15.8
SW Up Sfc	154.1	1048	-22.7	28.6	36.5	--------	--------
LW Up TOA	274.8	3597	-0.3	5.2	5.2	--------	-1.1
SW Up TOA	196.5	1844	-0.2	5.7	5.7	--------	5.9

Clear Sky MODIS & L/AA

	Obs Mean	N	Bias CRS-Obs	Std Dev	RMS	Dif Bias CRS-Obs	AOT Frc Clr-Prs
LW Dn Sfc	283.9	569	-12.5	14.4	19.0	--------	1.7
LW Up Sfc	439.3	497	-0.7	20.3	20.3	--------	--------
SW Dn Sfc	702.9	567	-0.3	19.1	19.1	--------	-14.1
SW Up Sfc	148.4	489	-20.4	24.0	31.5	--------	--------
LW Up TOA	285.0	574	0.6	5.5	5.5	--------	-0.8
SW Up TOA	174.6	572	-0.2	5.7	5.7	--------	4.4

Overcast MODIS

	Obs Mean	N	Bias CRS-Obs	Std Dev	RMS	Mod Frc All-Clr	Forcing All-CNA
LW Dn Sfc	313.2	4732	-7.7	24.2	25.4	45.2	0.4
LW Up Sfc	339.1	2328	1.5	22.3	22.4	--------	--------
SW Dn Sfc	241.3	2552	23.8	99.8	102.6	-274.4	-4.8
SW Up Sfc	73.8	1203	-10.6	52.3	53.3	--------	--------
LW Up TOA	178.0	4825	1.5	10.0	10.1	-55.5	-0.1
SW Up TOA	390.6	2508	15.9	28.3	32.5	204.8	0.3

Overcast MODIS & L/AA

	Obs Mean	N	Bias CRS-Obs	Std Dev	RMS	Mod Frc All-Clr	Forcing All-CNA
LW Dn Sfc	349.1	870	-5.1	15.0	15.8	52.8	0.3
LW Up Sfc	364.0	676	5.1	19.9	20.6	--------	--------
SW Dn Sfc	212.3	868	29.0	106.4	110.2	-406.1	-5.4
SW Up Sfc	46.9	647	-4.0	53.2	53.3	--------	--------
LW Up TOA	186.8	863	4.5	10.3	11.2	-60.7	-0.1
SW Up TOA	478.0	871	12.2	27.7	30.3	318.9	-0.2

Bias = (Untuned Calculations minus Observations)

Terra CRS Edition 2B Jan.-Dec. 2001

CAVE surface radiometer "CVS" record.

TOA observations from CERES broadband instrument.

Aerosol forcing as all-sky computation with aerosols

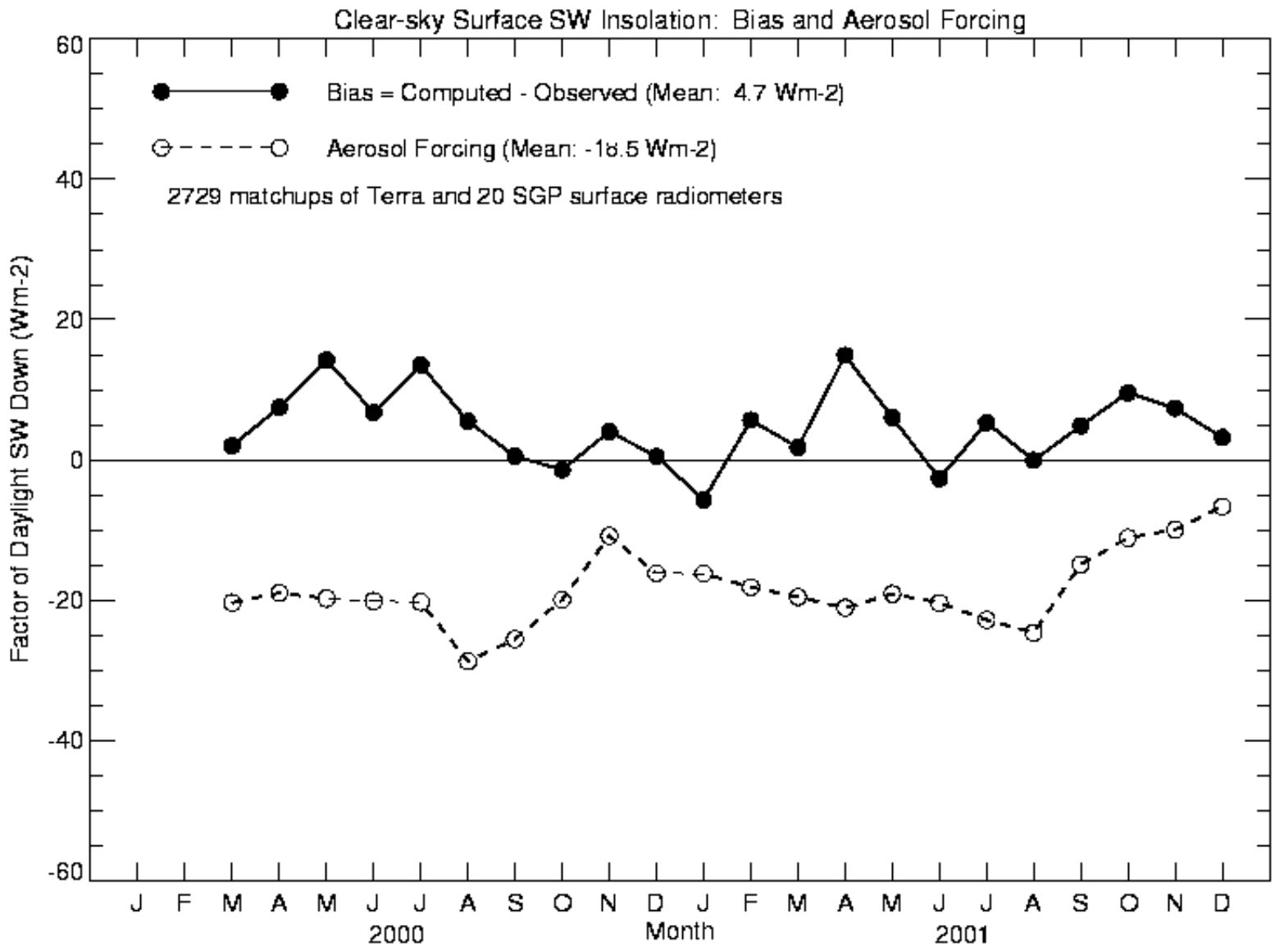
minus all-sky sky computation without aerosols.

	Observed Mean	N	Bias	RMS	Aerosol Forcing
ALL SKY	Wm-2		Wm-2	Wm-2	Wm-2
LW Down Surface	286.0	22420	-6.1	24.4	1.1
SW Down Surface	444.3	10938	13.1	94.5	-9.7
LW Up TOA	218.8	22885	1.4	8.8	-0.4
SW Up TOA	261.0	10873	10.7	28.2	3.4

SW bias for ~1030 LST daylight overpass
Daily bias is smaller by factor of ~3
Clear sky insolation bias is only -0.4 Wm-2, much less than the clear sky aerosol forcing of -15.8 Wm-2.

Bias (calculated - observed) and Aerosol Forcing Clear-sky SW insolation at **SGP** (2000-2001)

CRS Terra FM1/FM2 Edition 2B



Bias = (Untuned Calculations minus Observations)

Terra CRS Edition 2B Jan.-Dec. 2001

CAVE surface radiometer "CVS" record.

TOA observations from CERES broadband instrument.

Aerosol forcing as all-sky computation with aerosols

minus all-sky sky computation without aerosols.

	Observed Mean	N	Bias	RMS	Aerosol Forcing
ALL SKY	Wm-2		Wm-2	Wm-2	Wm-2
LW Down Surface	286.0	22420	-6.1	24.4	1.1
SW Down Surface	444.3	10938	13.1	94.5	-9.7
LW Up TOA	218.8	22885	1.4	8.8	-0.4
SW Up TOA	261.0	10873	10.7	28.2	3.4

SW biases & RMS are mostly due to clouds (aka cloud forcing).
Observations have ~ (13.1+10.7=23.8 ~~24.8~~ Wm-2) more absorption by atmosphere, than do calculations.
Remember: This ~23.8 Wm-2 "anomaly" represents 1030 LST.

Bias = (Untuned Calculations minus Observations)

Terra CRS Edition 2B Jan.-Dec. 2001

CAVE surface radiometer "CVS" record.

TOA observations from CERES broadband instrument.

Aerosol forcing as all-sky computation with aerosols

minus all-sky sky computation without aerosols.

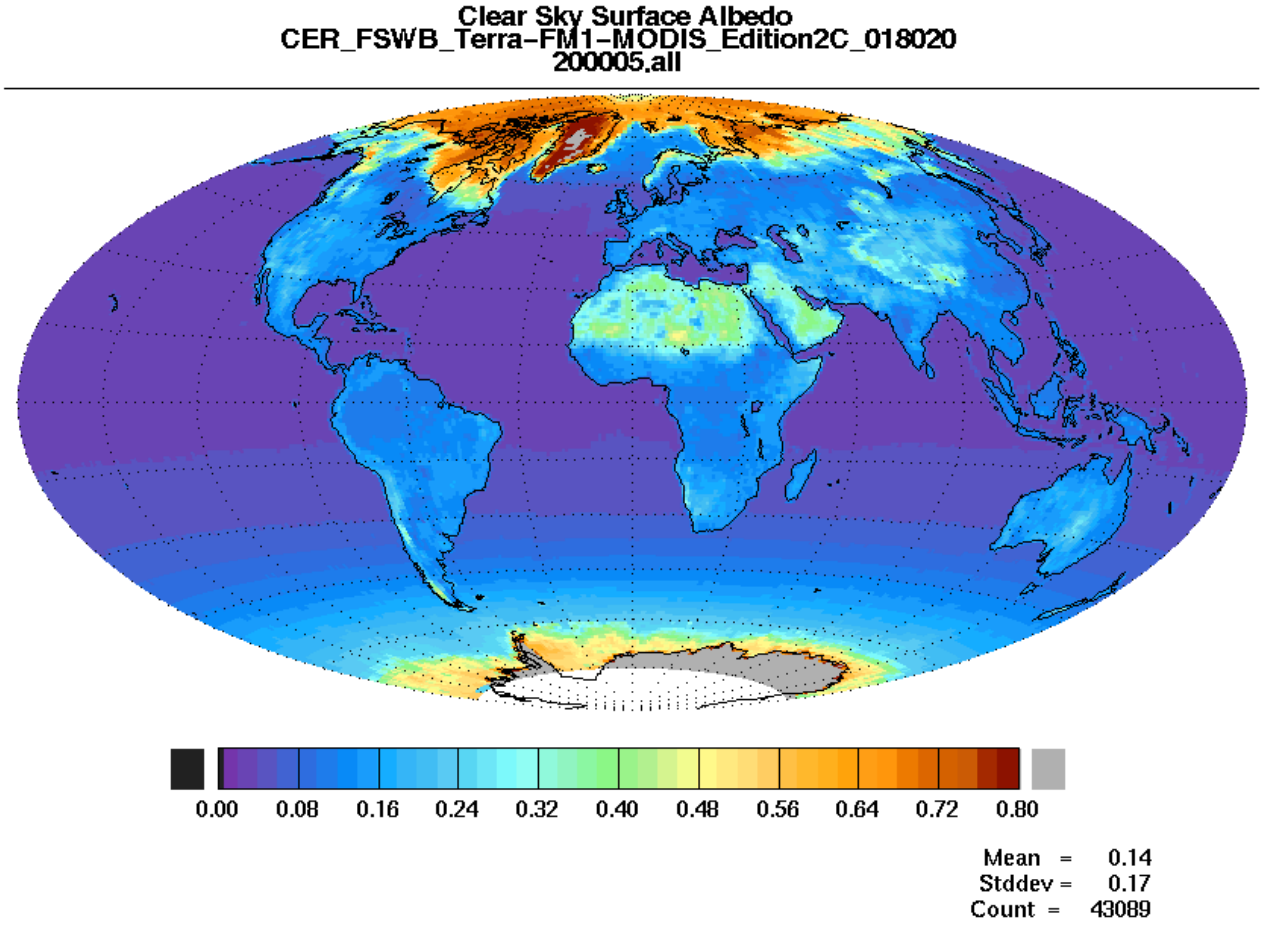
	Observed Mean	N	Bias	RMS	Aerosol Forcing
ALL SKY	Wm-2		Wm-2	Wm-2	Wm-2
LW Down Surface	286.0	22420	-6.1	24.4	1.1
SW Down Surface	444.3	10938	13.1	94.5	-9.7
LW Up TOA	218.8	22885	1.4	8.8	-0.4
SW Up TOA	261.0	10873	10.7	28.2	3.4

Observations have -6.1 Wm-2 more downwelling LW than do calculations. This is mostly due to the input surface air temperature (GMAO). ECMWF was better. Cloud effects are "no problem" for LW here.

Q: What use is all this CERES SARB "in atmosphere" Wm^{-2} to a GCM?

A: If it's sufficiently consistent with observations, it's a gridded target for GCM validation; a shorthand over the cloud/aerosol properties. Translating τ_{model} to $\tau_{satellite}$ is awful. Translating Wm^{-2} is easy.

FSW: The hourly gridded CERES product



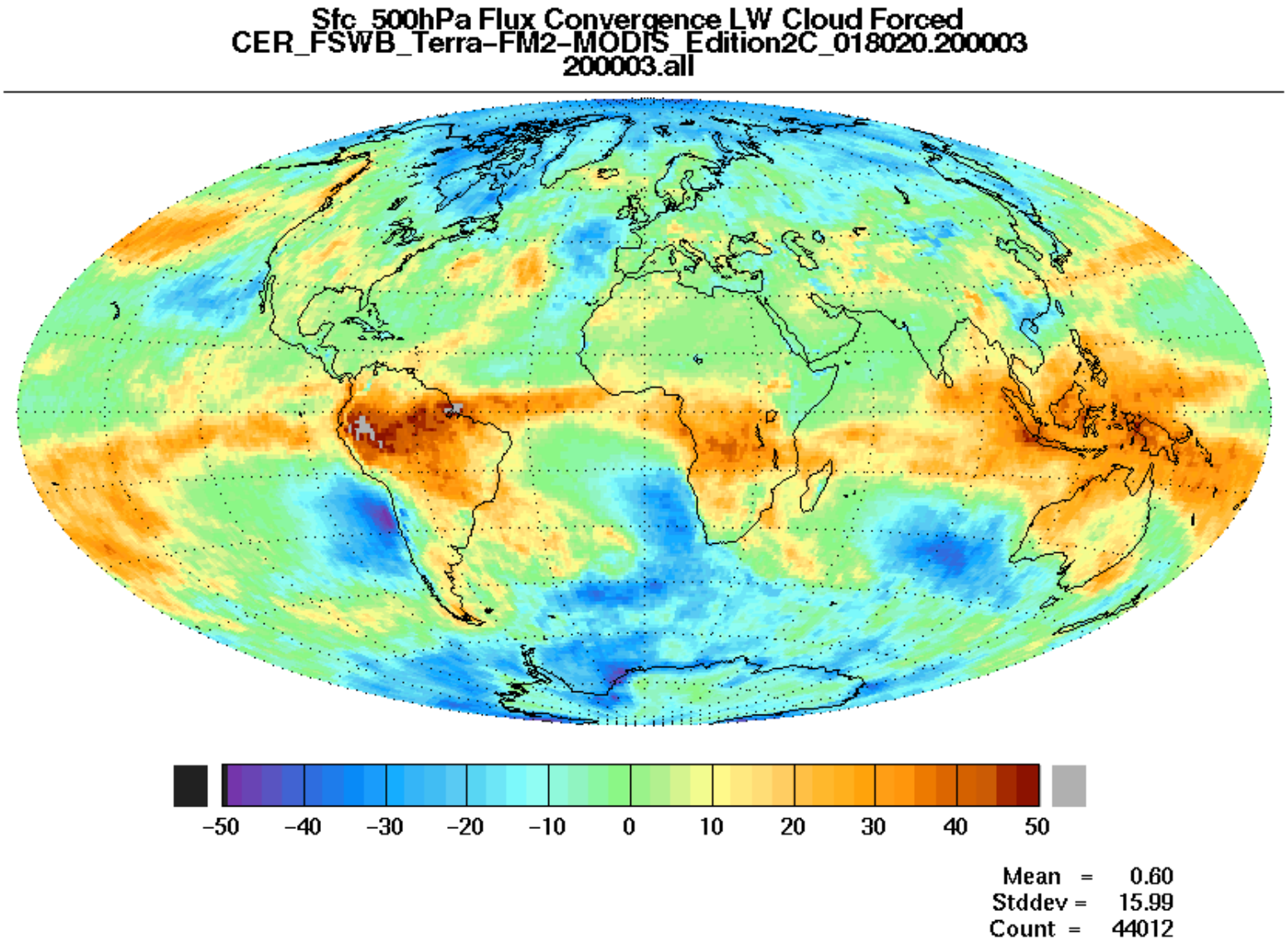
http://asd-www.larc.nasa.gov/sarb/Pindex.html

Tables/plots of official global product

(temporary password: "caveman")

Cloud forcing to LW Convergence (Surface - 500 hPa) for March 2000

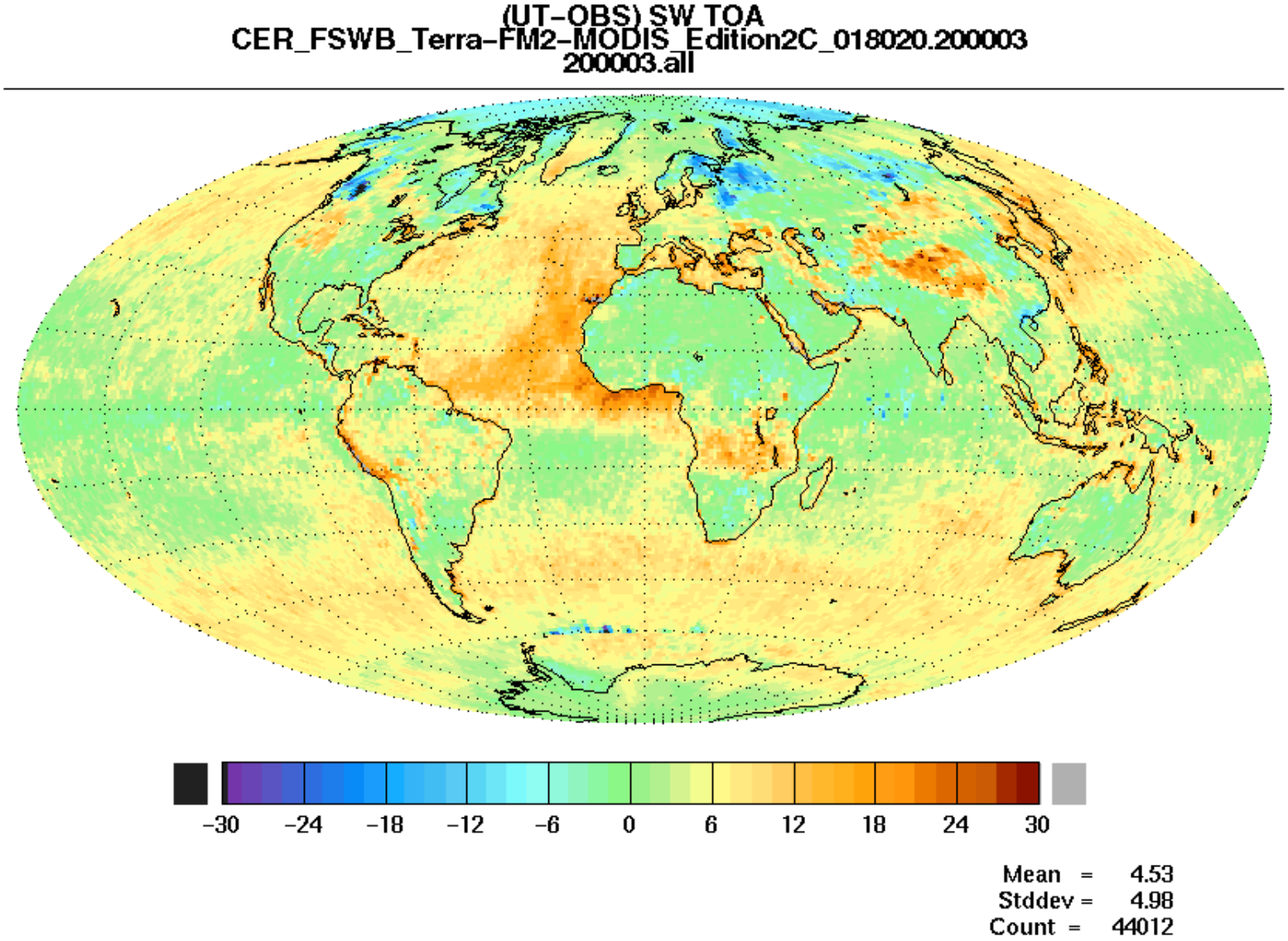
FSW: The hourly gridded CERES product



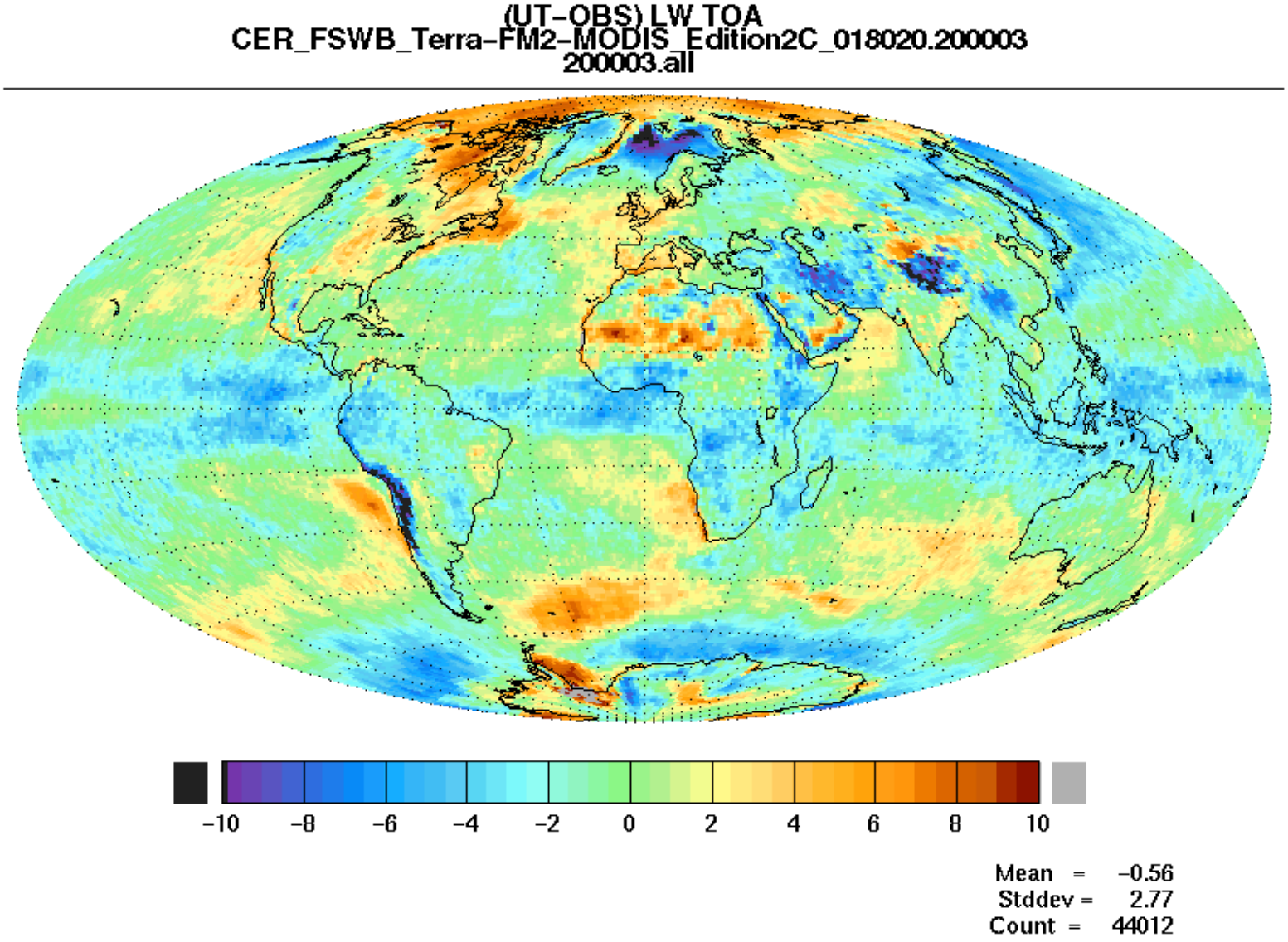
Bias at TOA (Untuned SW - Observed) for March 2000 as 24-hour mean

FSW: The hourly gridded CERES product

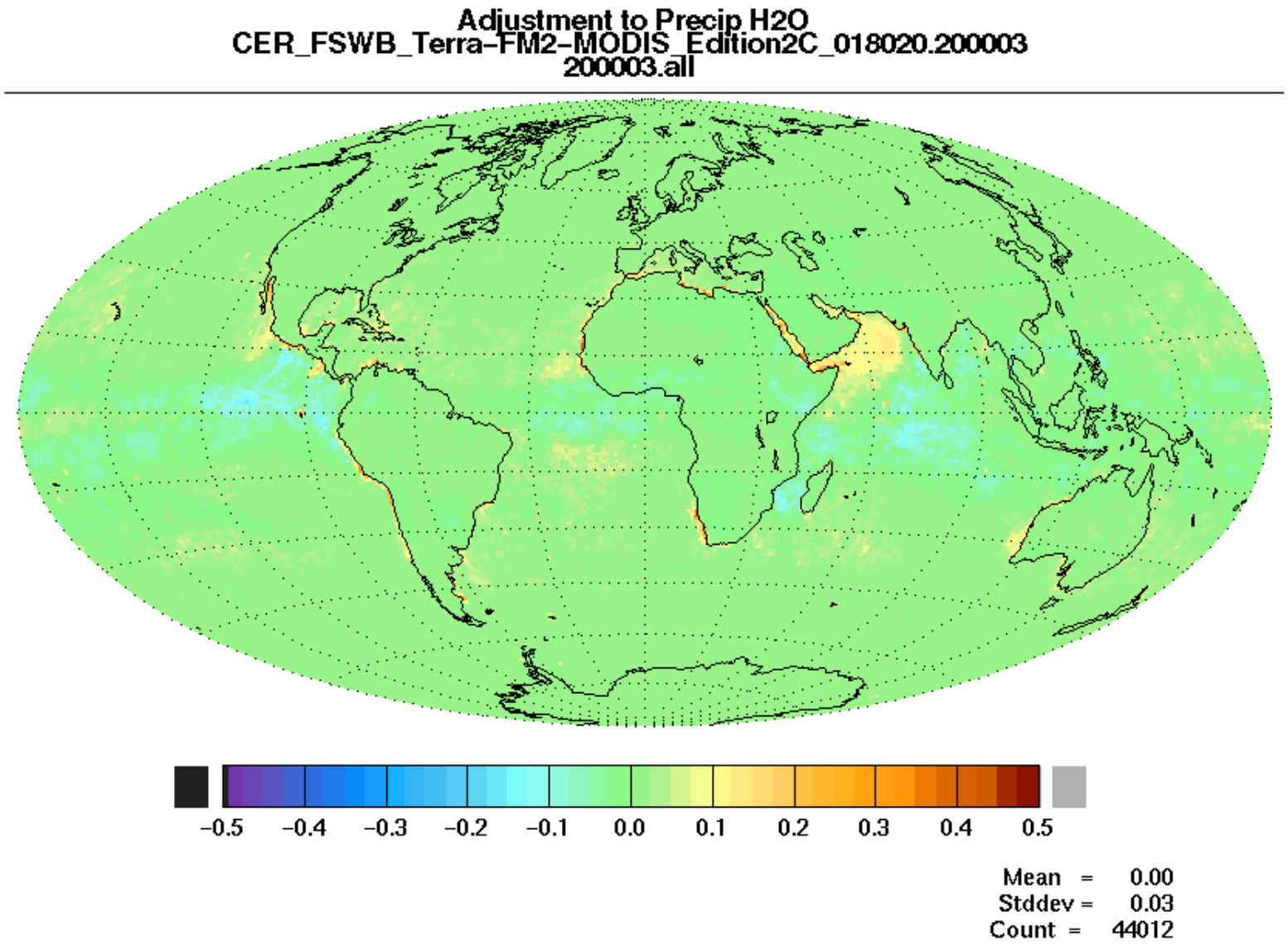
The computed SW reflects too much at TOA. This is a persistent problem.



All-Sky OLR Bias (Untuned - Observed) for March 2000 as 24-hour mean

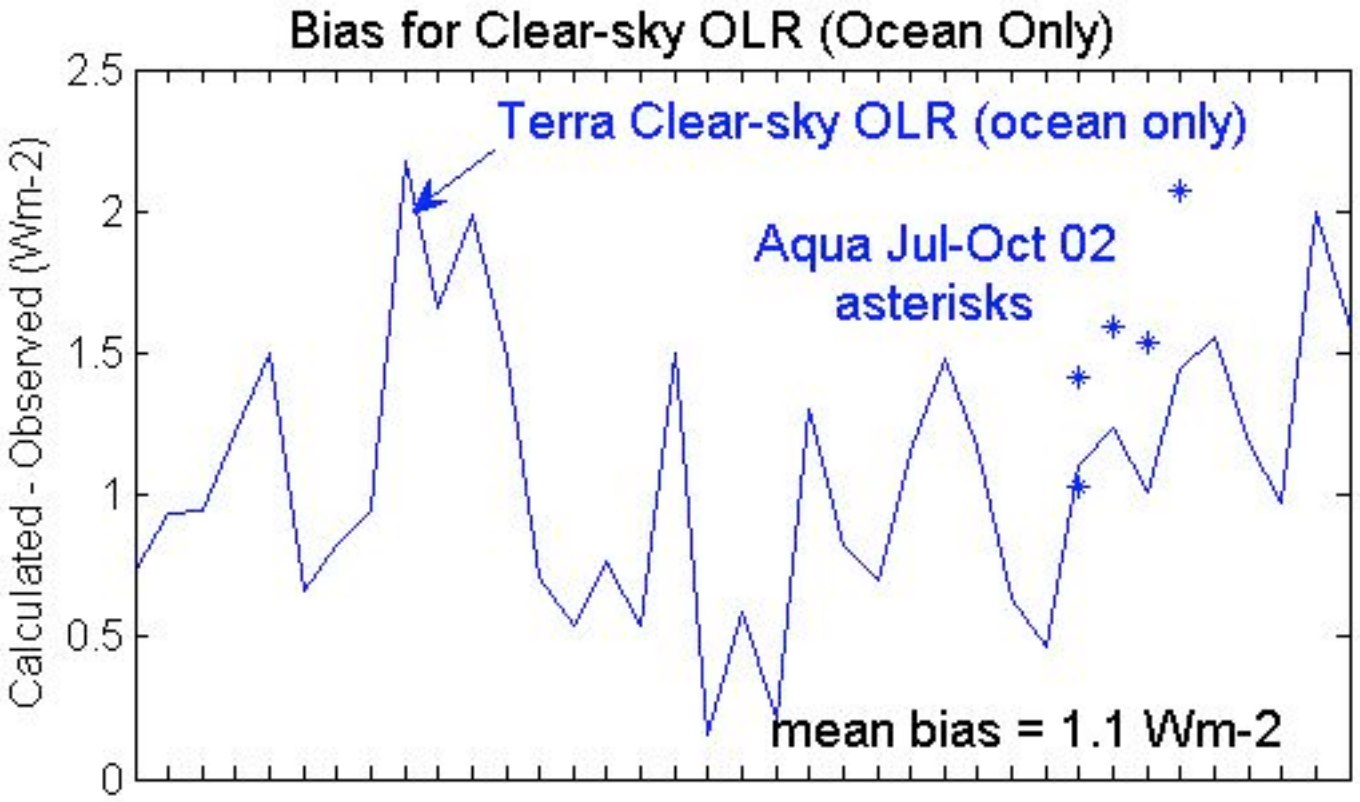


Adjustment to PW by SARB Tuning (March 2000)



Bias (Untuned - Observed) for Clear-sky OLR over Ocean

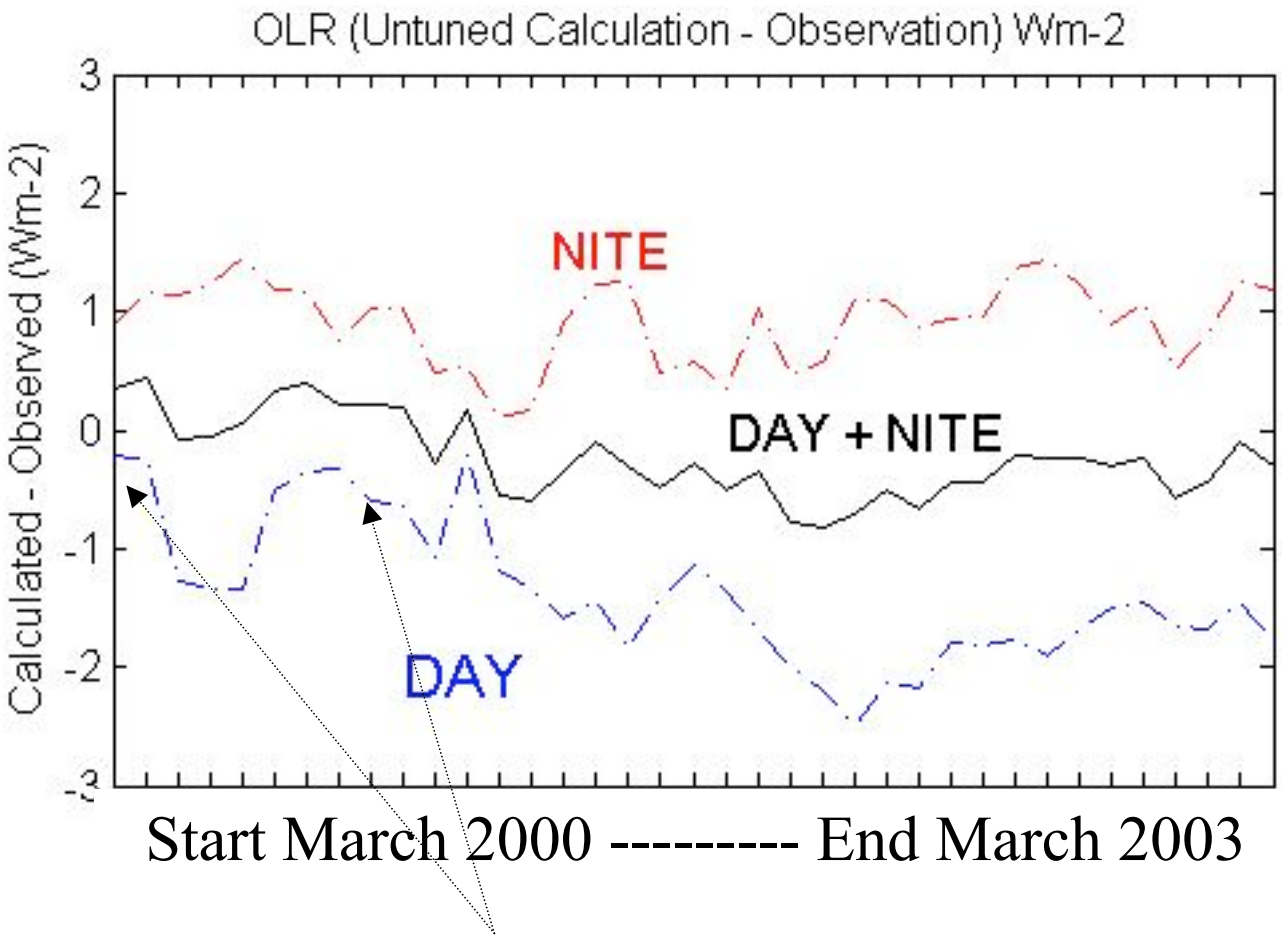
CER FSWB Edition 2C Terra FM1/FM2 and Aqua FM3/FM4



Start March 2000 ------- End March 2003

Bias (Untuned - Observed) for All-sky OLR

CER FSWB Edition 2C Terra FM1/FM2

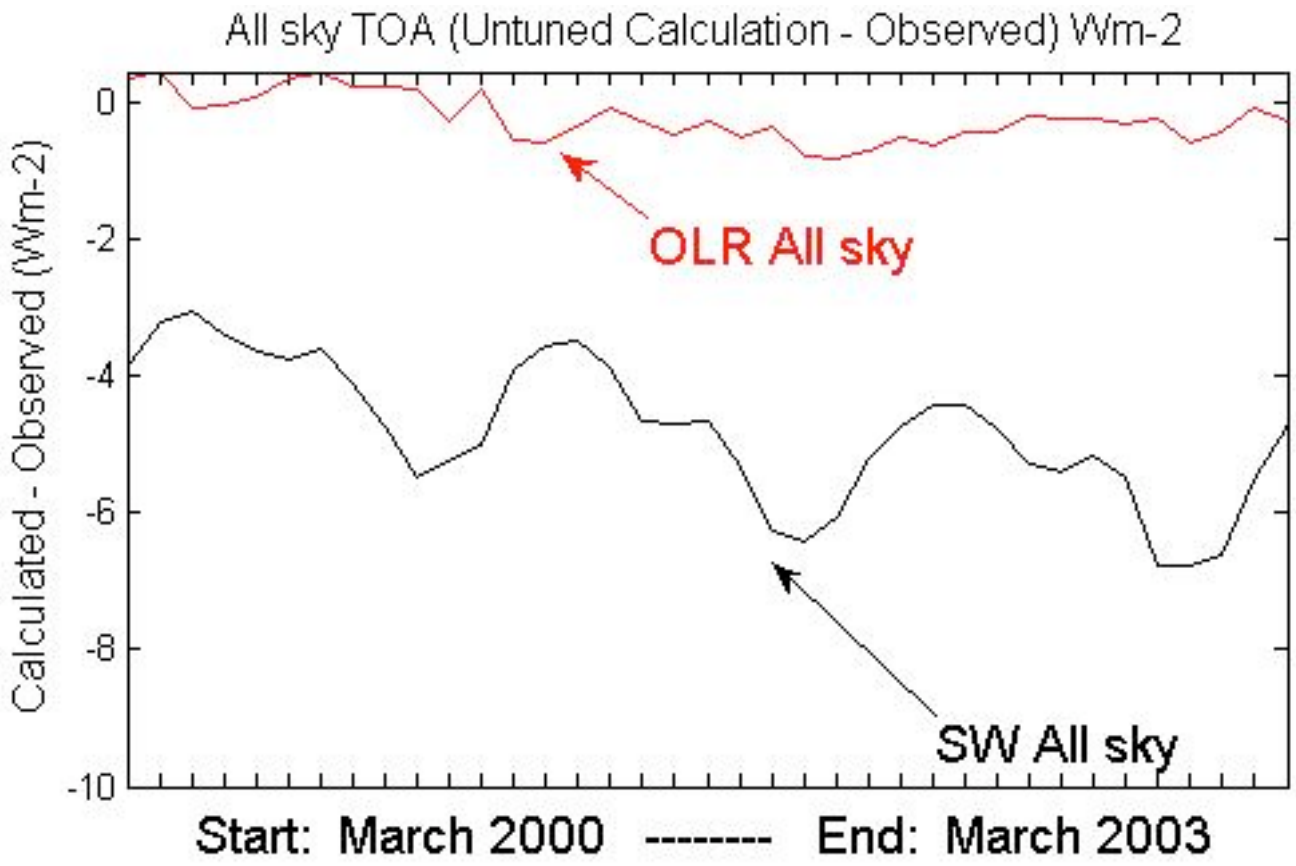


Start March 2000 --------- End March 2003

Terra FM2 (near start in spurts) has smaller bias

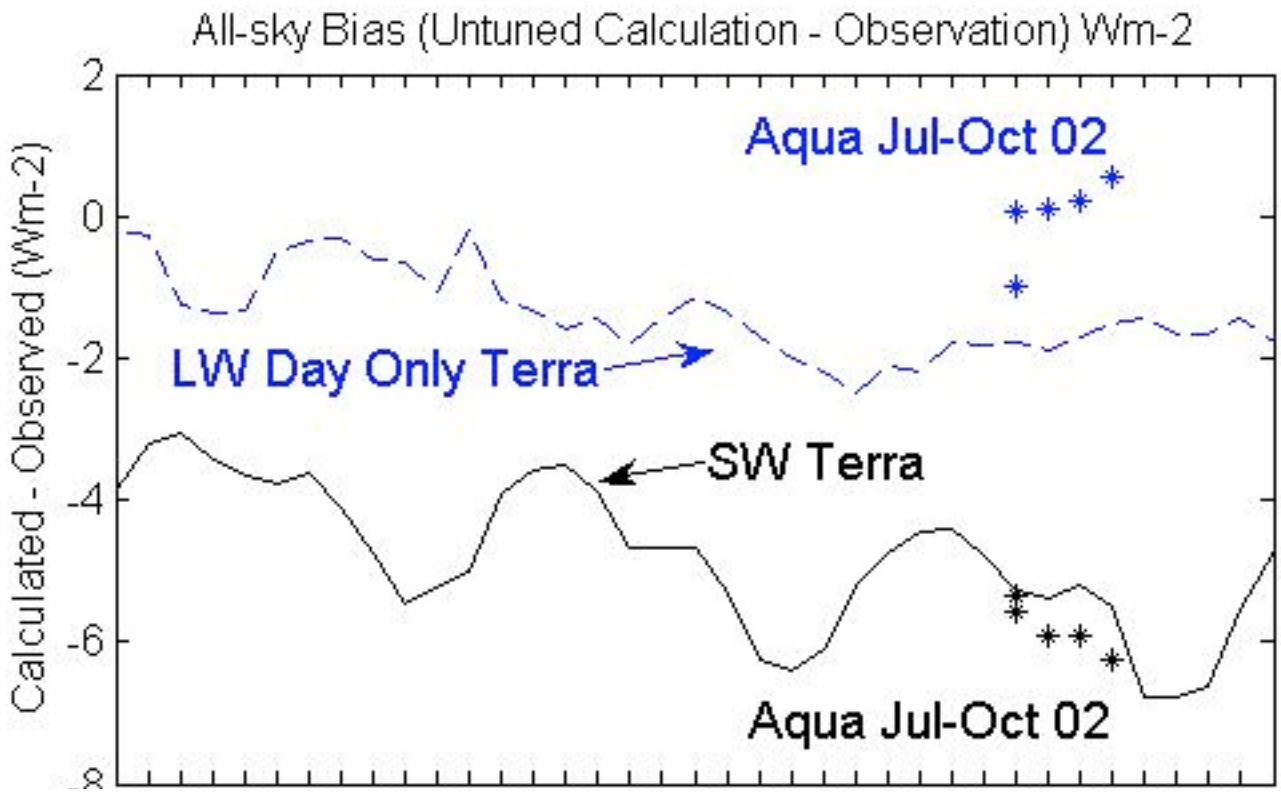
Bias (Untuned - Observed) for All-sky

CER FSWB Edition 2C Terra FM1/FM2



Bias (Untuned - Observed) for All-sky

CER FSWB Edition 2C Terra FM1/FM2 Aqua FM3/FM4

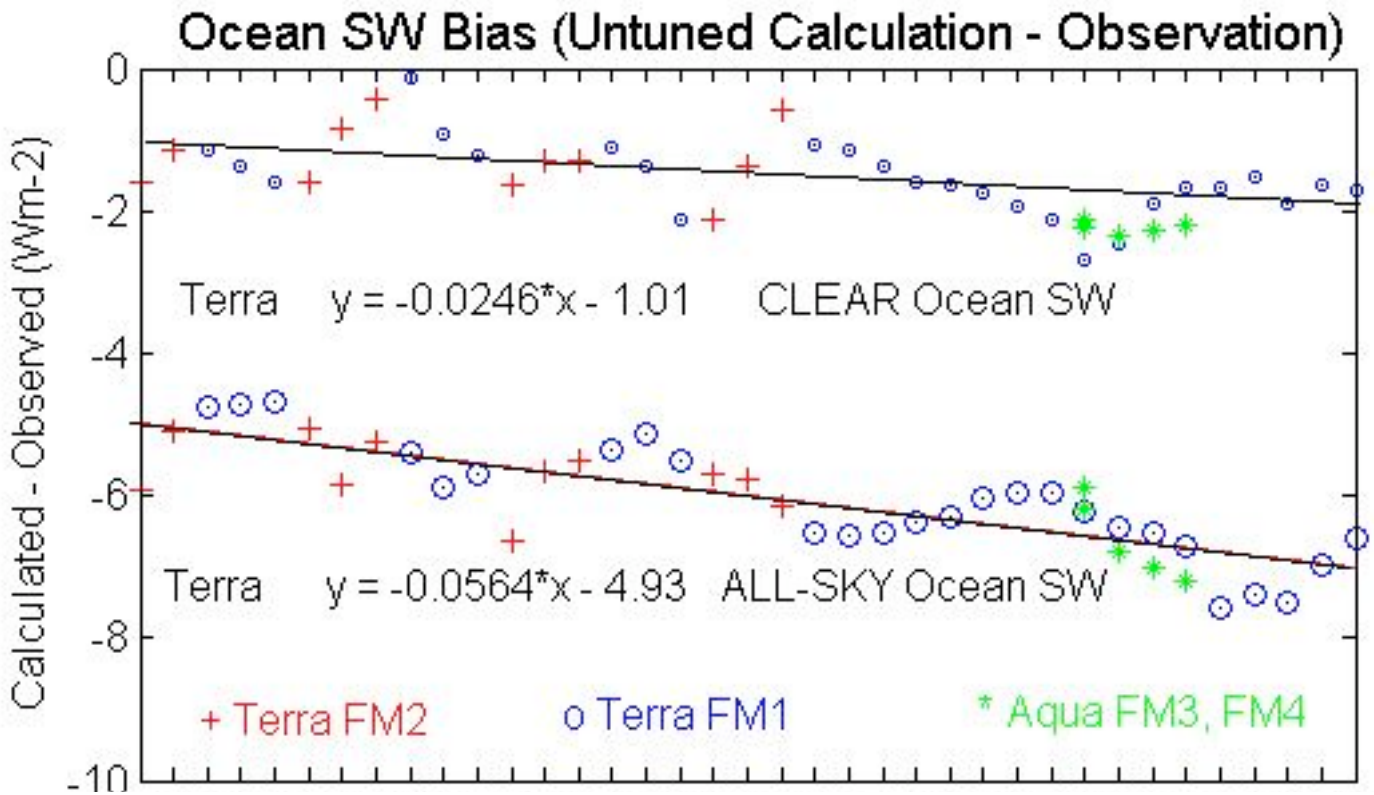


Start March 2000 ------- End March 2003

Bias (Untuned - Observed) over Ocean

Ice-free ocean calculation has no input from broadband instrument

CER FSWB Edition 2C Terra FM1/FM2 Aqua FM3/FM4



Start March 2000 --------- End March 2003

Bias = (Untuned Calculations minus Observations)

Terra CRS Edition 2B Jan.-Dec. 2001

CAVE surface radiometer "CVS" record.

TOA observations from CERES broadband instrument.

Aerosol forcing as all-sky computation with aerosols

minus all-sky sky computation without aerosols.

	Observed Mean	N	Bias	RMS	Aerosol Forcing
ALL SKY	Wm-2		Wm-2	Wm-2	Wm-2
LW Down Surface	286.0	22420	-6.1	24.4	1.1
SW Down Surface	444.3	10938	13.1	94.5	-9.7
LW Up TOA	218.8	22885	1.4	8.8	-0.4
SW Up TOA	261.0	10873	10.7	28.2	3.4

SW biases & RMS are mostly due to clouds (aka cloud forcing).
Observations have ~ (13.1+10.7=23.8 ~~24.8~~ Wm-2) more absorption by atmosphere, than do calculations.
Remember: This ~23.8 Wm-2 "anomaly" represents 1030 LST.

Fractional Error in Reflected SW (Untuned-Observed)

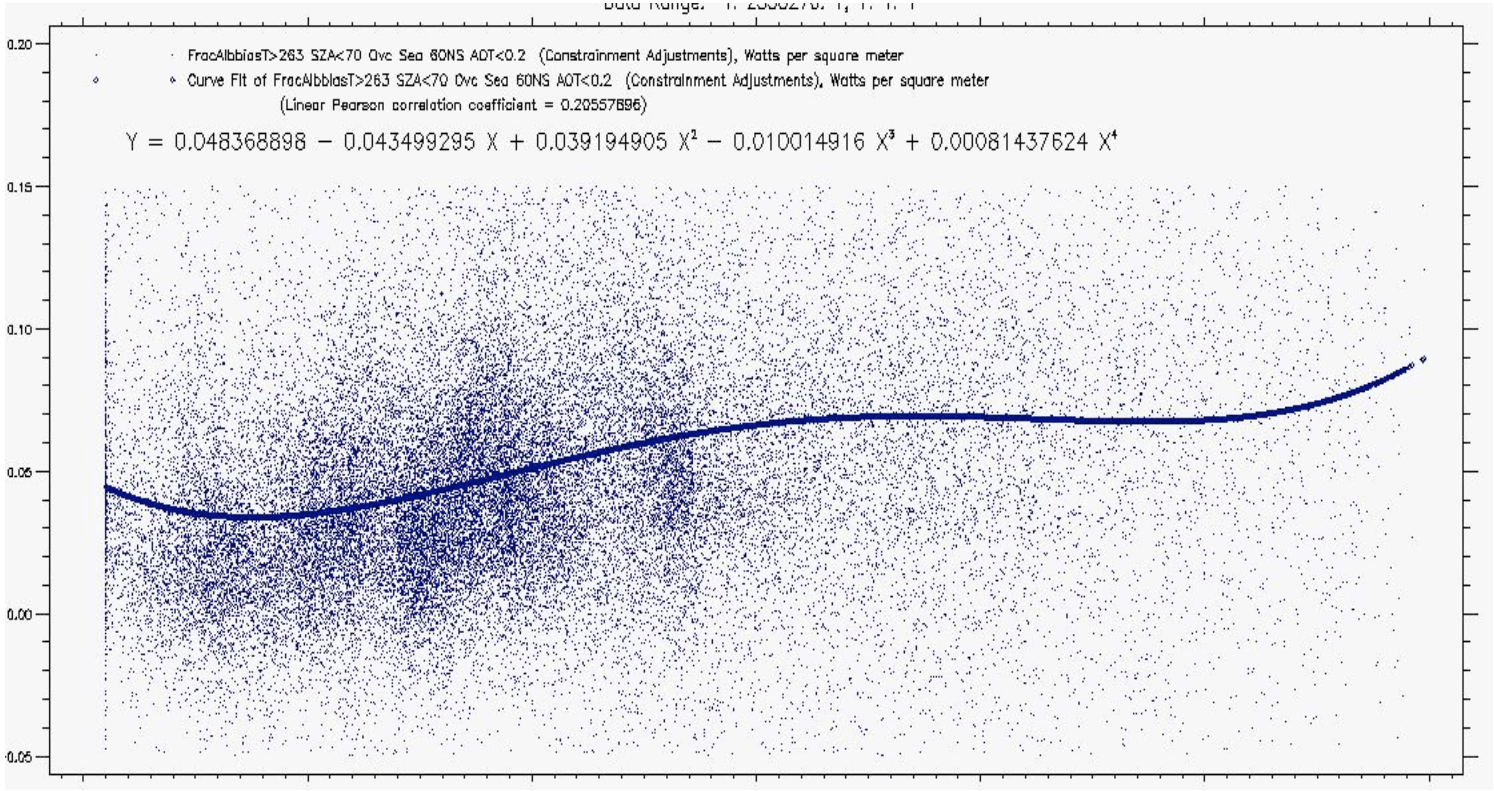
~~TOA Albedo Bias (Untuned - Observed)~~

Overcast water clouds over ocean 55N-55S (AOT<0.2)

Terra CRS FM1 Edition 2B 2 July 2000

Fractional Error

~~Albedo Bias (Untuned - Observed)~~



Cloud effective height

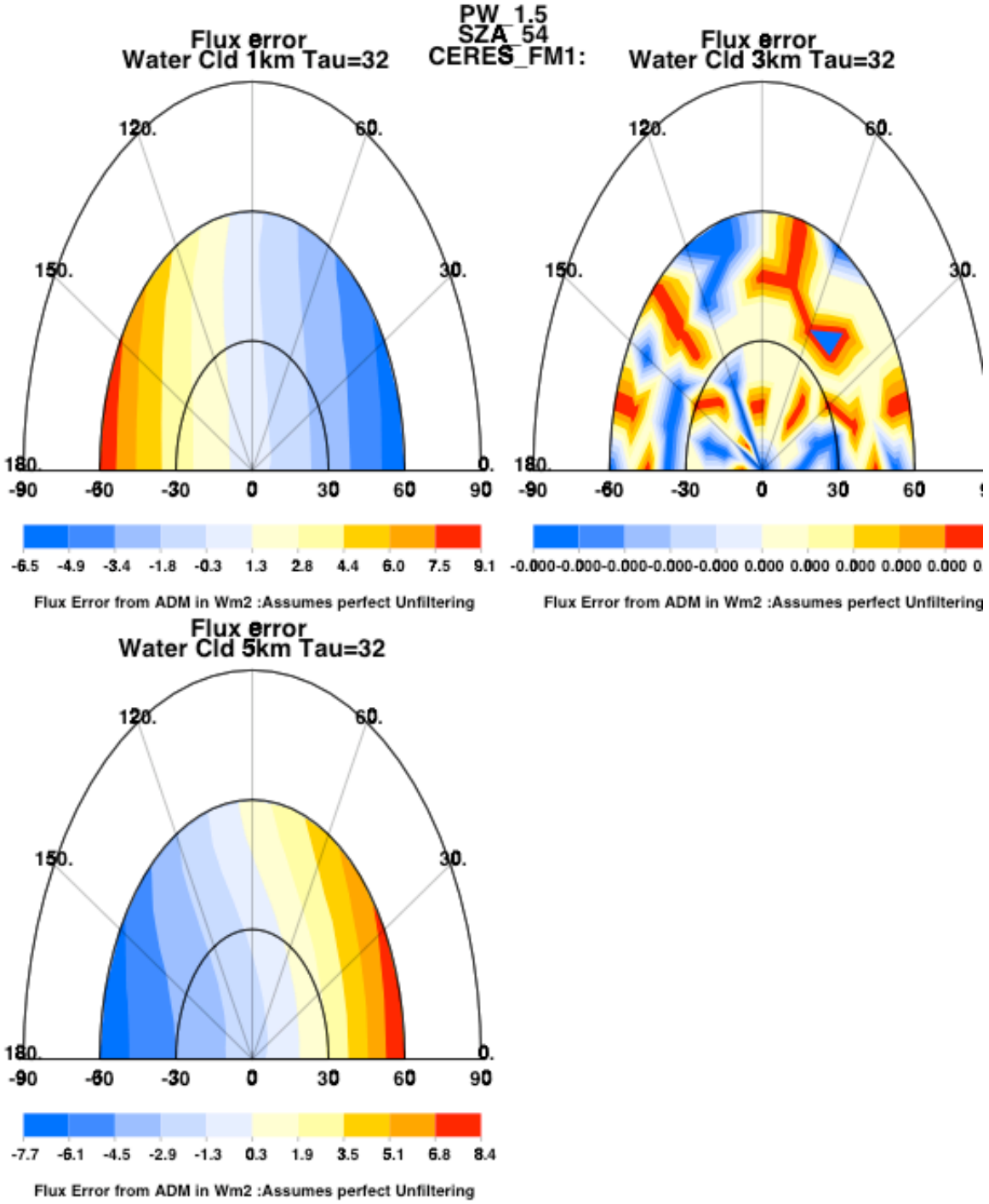
Fractional Error = (Calculated-Observed)/(Observed)

Theoretical ADM with COART:
A pure theory to theory look

Universe = 3 clouds with tops at 1, 3, and 5 km

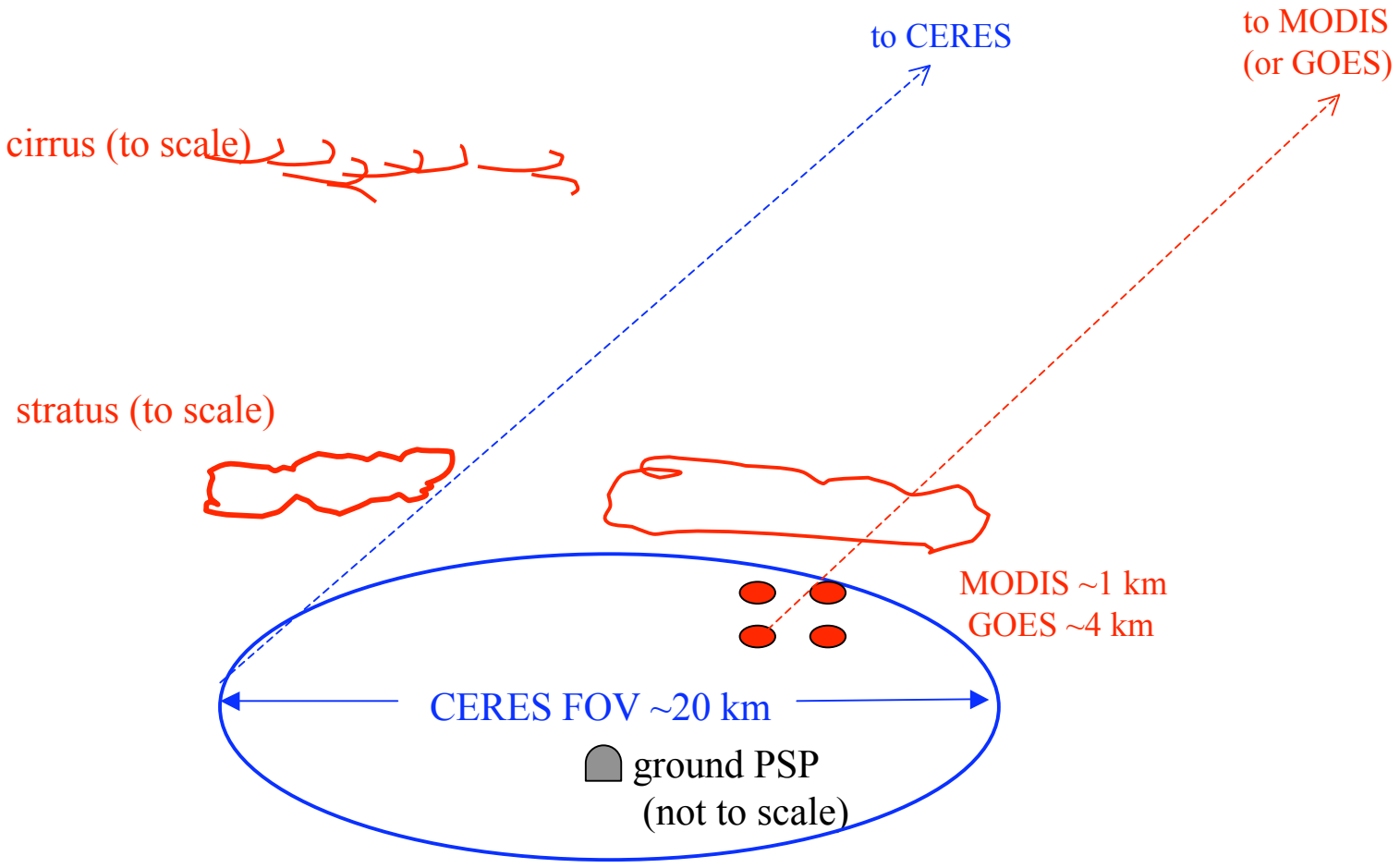
Produce single mean ADM and apply it.

Errors for 1 km, 5 km clouds significant for some angles



Q.: How do we reconcile the broadband heating rate, surface to TOA, on such scales?

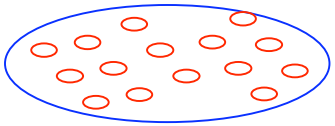
A.: Look for cases where probablity distribution function of transmission (surface to TOA) is consistent. Use the spatial distribution from satellite and temporal distribution from the surface.



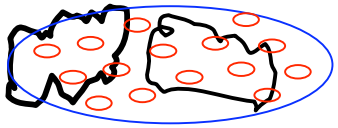
Probability Distribution Function for Transmission (TOA to surface)

SPACE

A typical CERES FOV (or ARM gridbox) contains many MODIS (or GOES imager) pixels:



Imager gets cloud optical depth **τ** for each pixel:

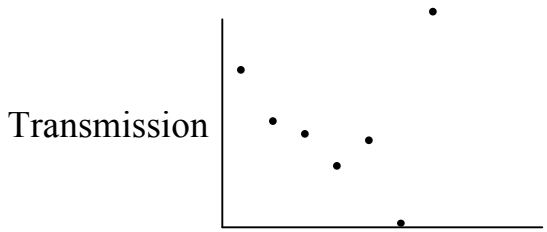


This is an actual **spatial** probability distribution function (pdf) for TOA to surface transmissivity T computed over SGP E-13 with the Fu-Liou code. The input cloud **τ** are from a single CERES FOV (Terra SSF Edition 2B) with MODIS radiances using the Minnis algorithm:

TIME

A surface radiometer (PSP) measures insolation. This can be expressed as a minute-by-minute time series of transmission T. The time series of yields a temporal probability distribution function (pdf) for TOA to suface transmissivity T.

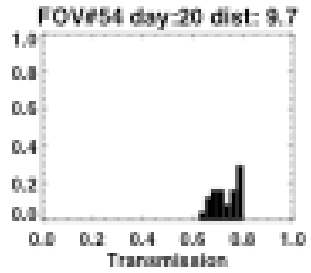
Idealized PSP time series



This is the temporal probability distribution function (pdf) for T over SGP E-13 for the 60 minute interval of the satellite observation on the left:

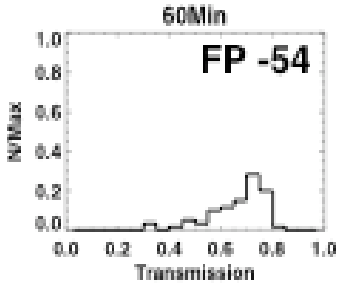
Real data matched in space (left) and time (right)

Population



Transmission

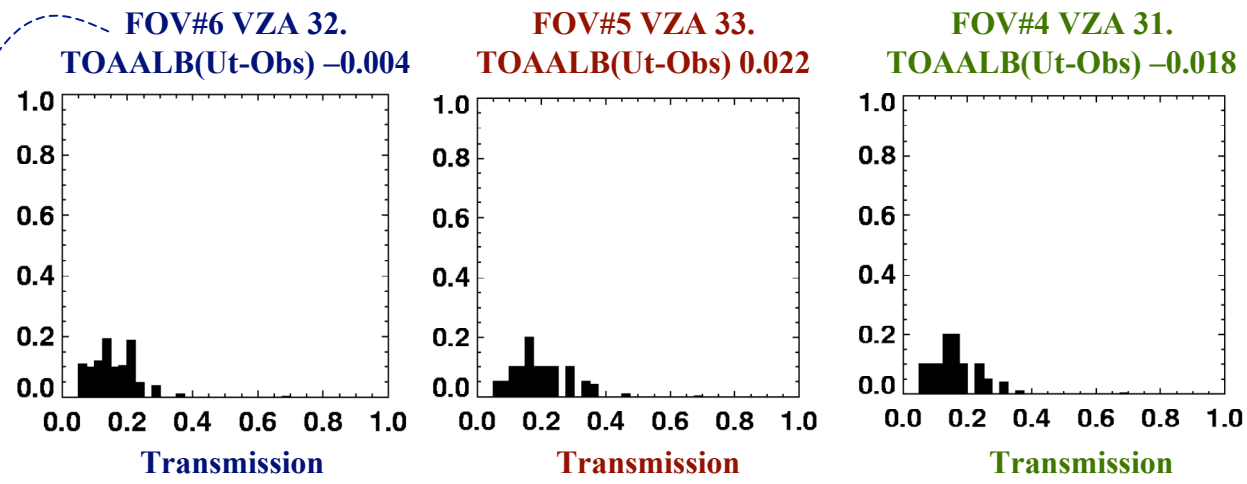
Population

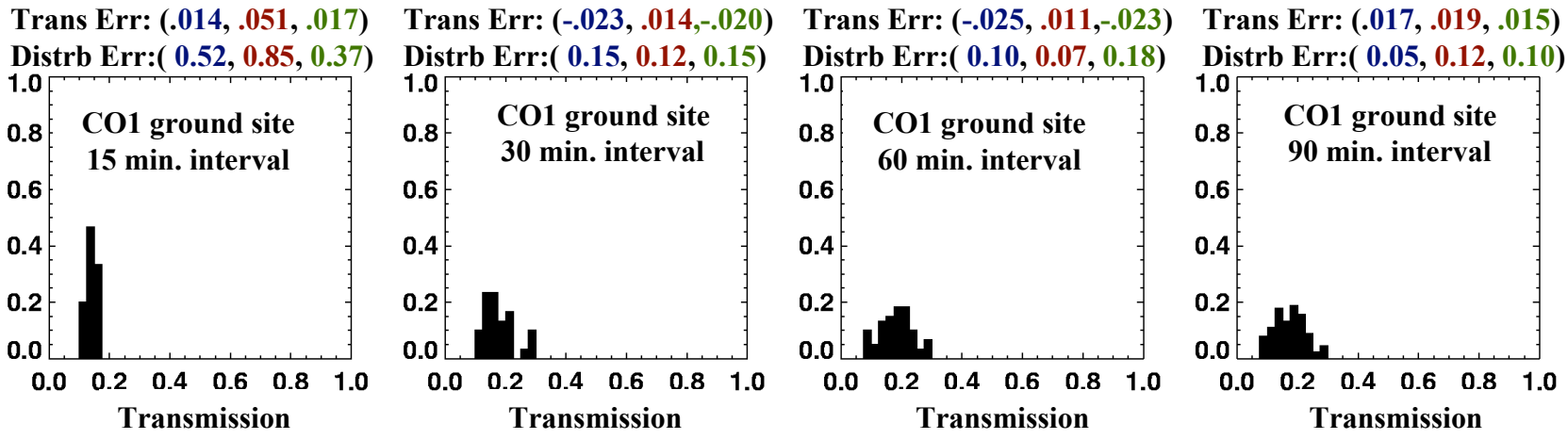


Transmission

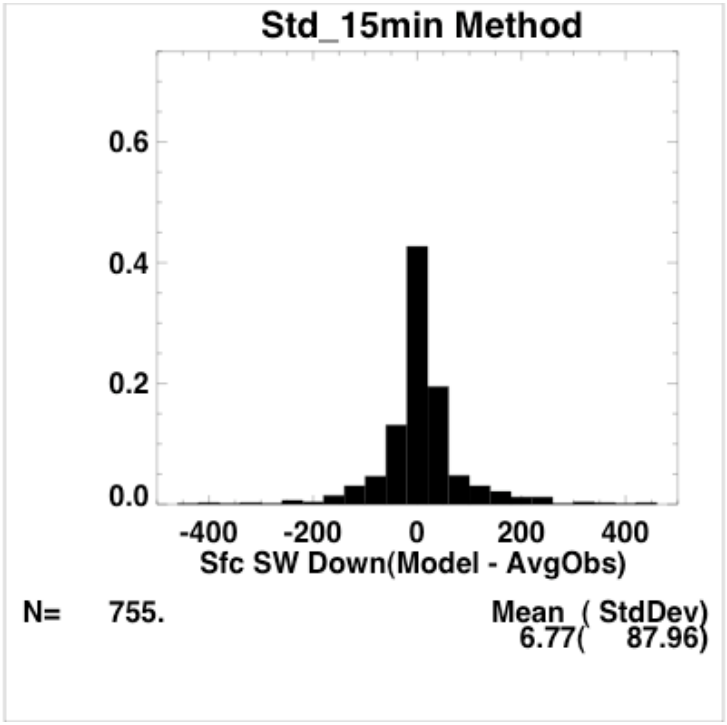
Computed spatial PDFs of transmission from three adjacent satellite FOVs

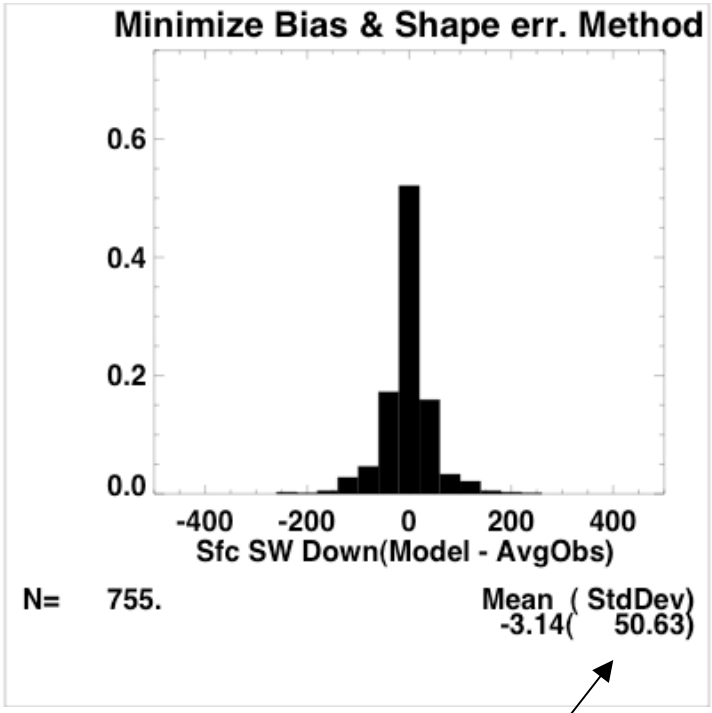
April 2 2001 C01
FOV Distances
(8.6, 12.9, 14.7) km

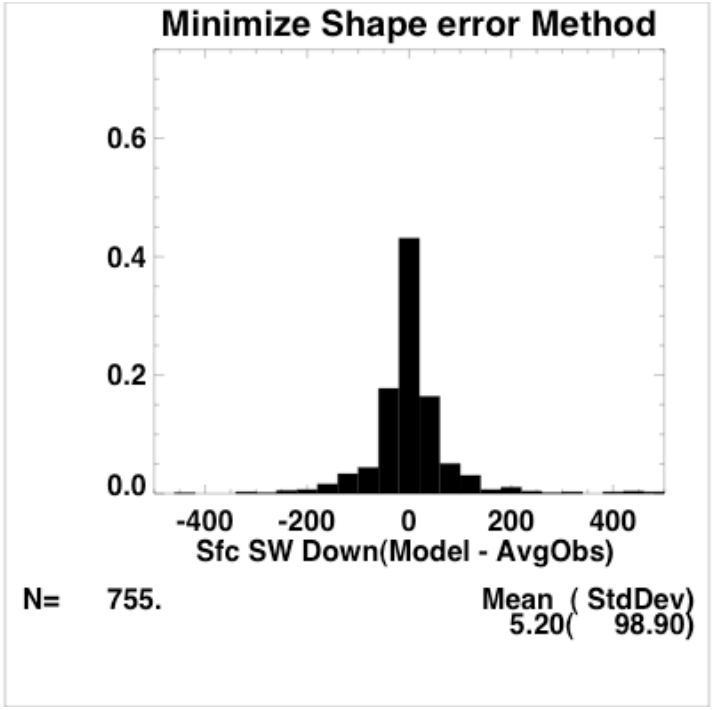




Observed PDFs of transmission at C01 ground site using from temporal records of four lengths



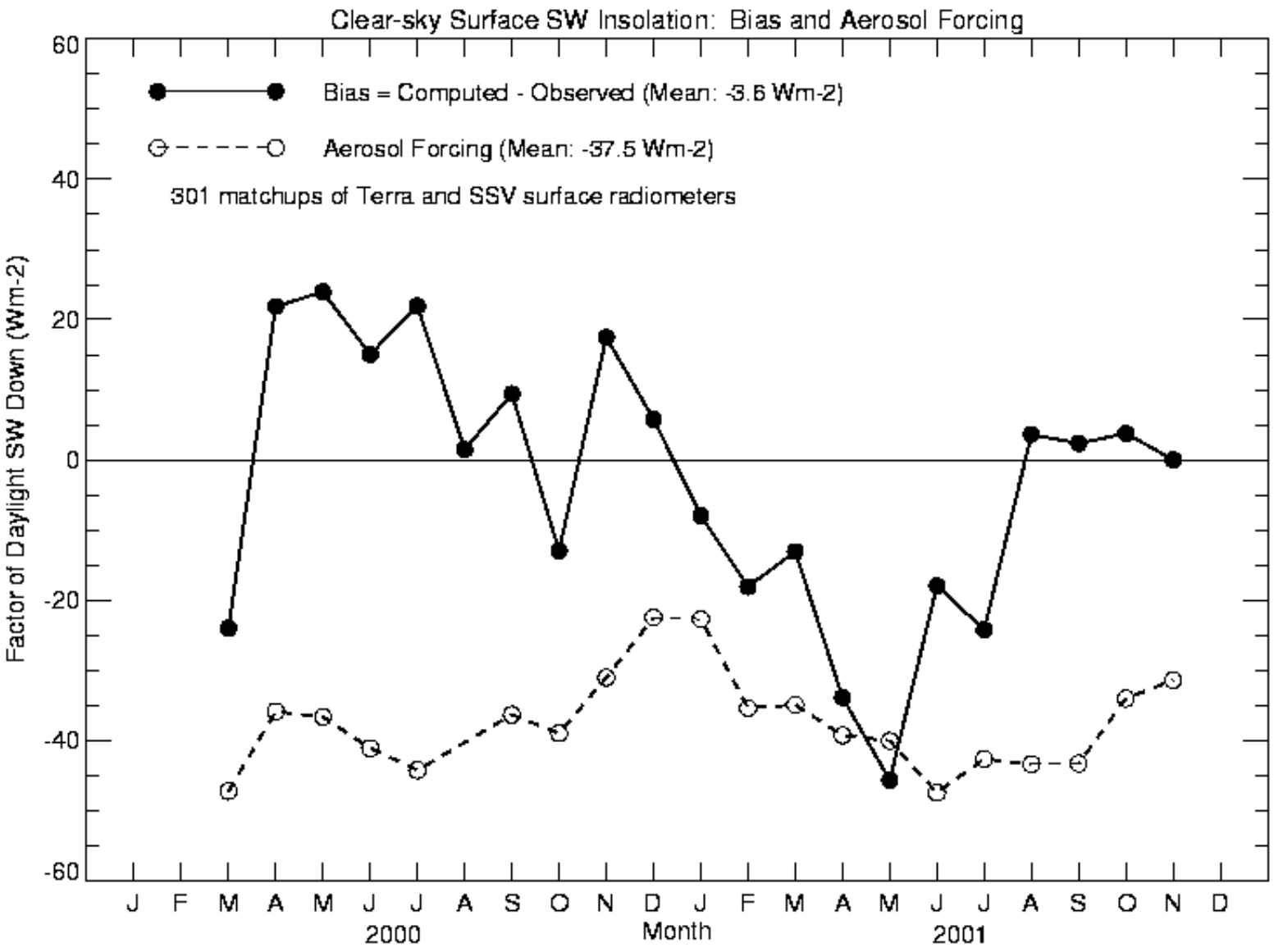




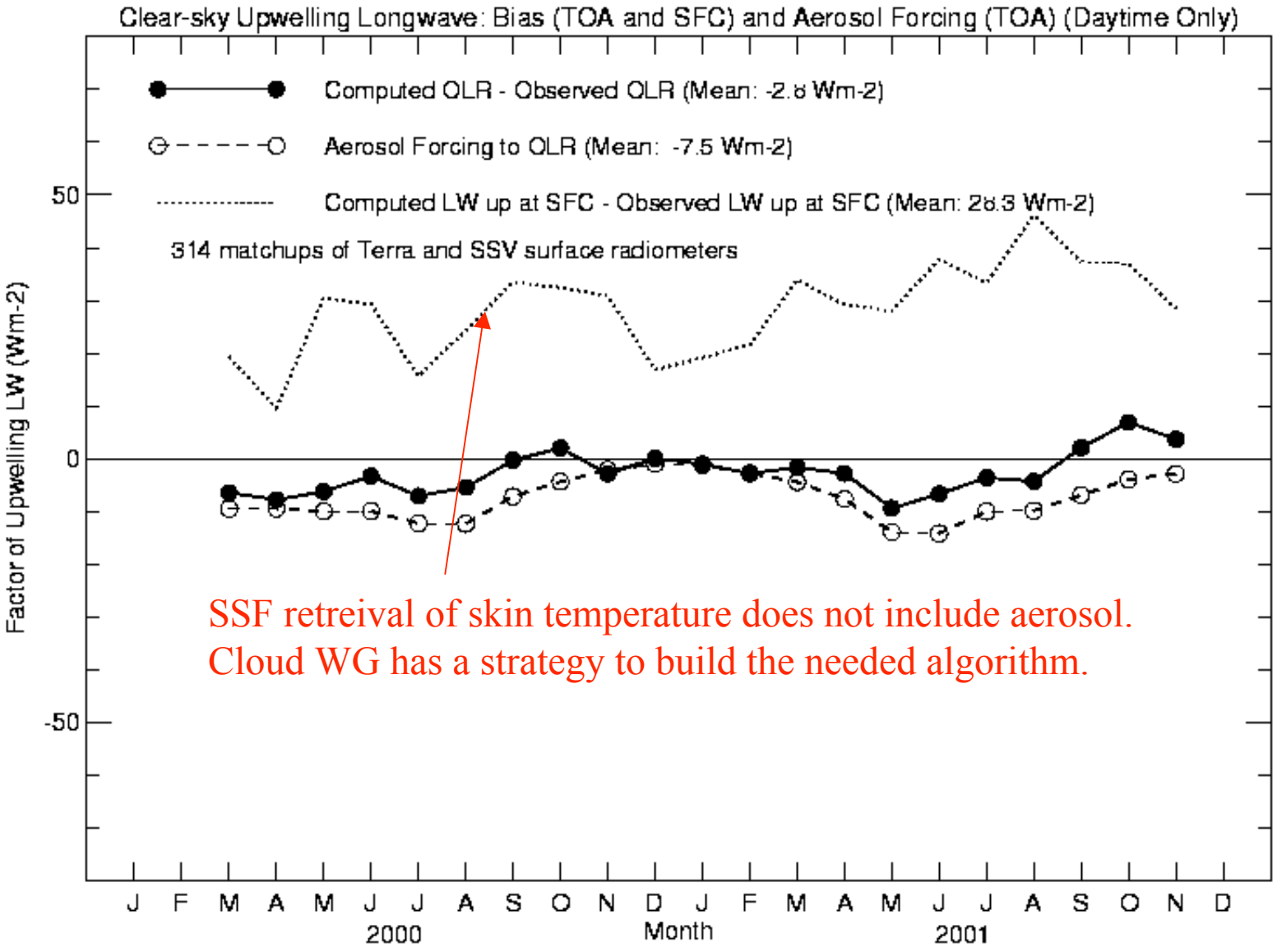
Reduced Std Dev with preliminary algorithm

Bias (calculated - observed) and Aerosol Forcing
Clear-sky SW insolation at **Saudi Solar Village** (2000-2001)

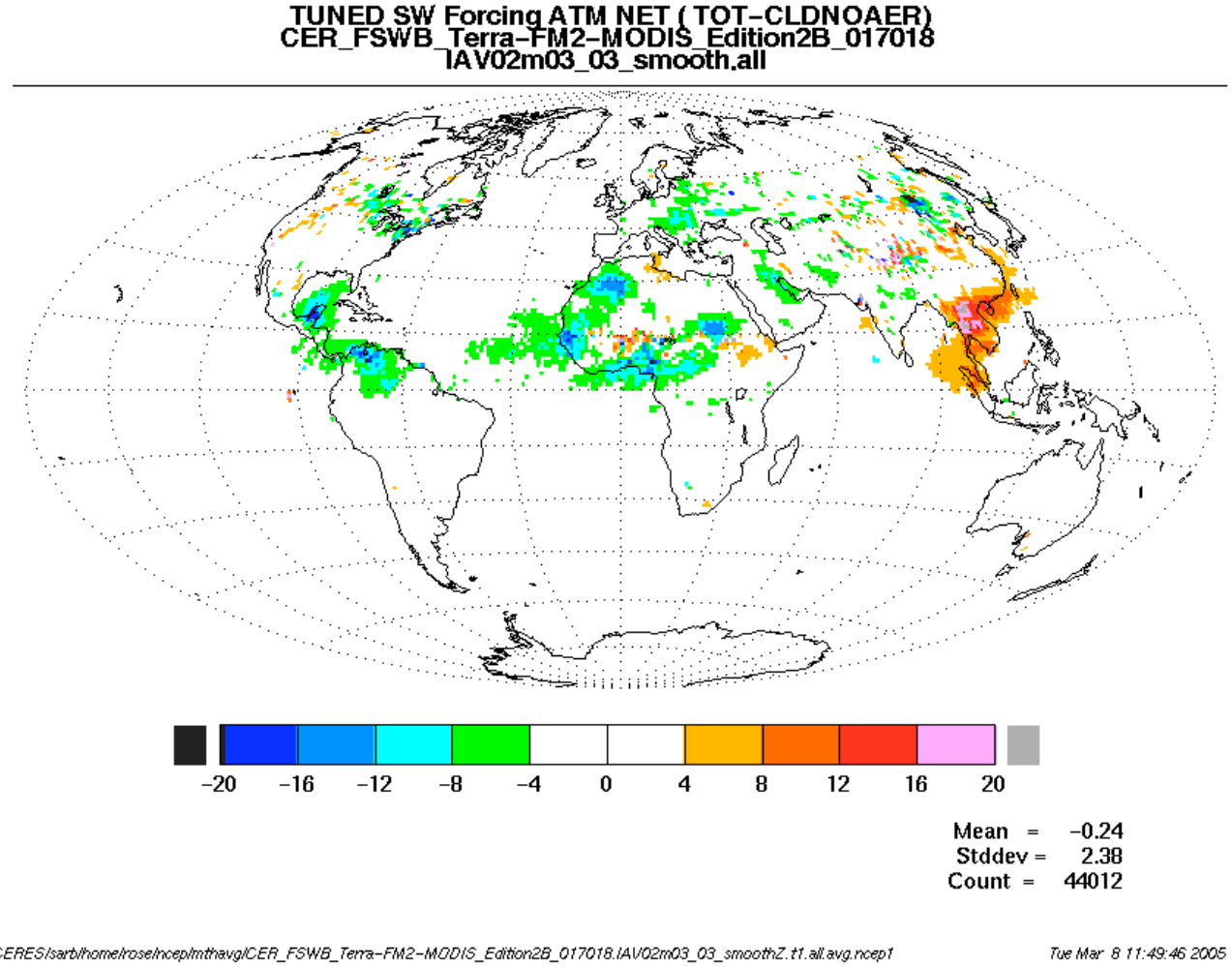
CRS Terra FM1/FM2 Edition 2B



Aerosol Forcing to OLR and Bias for OLR and LW up at surface
Clear-sky upwelling LW at **Saudi Solar Village** (2000-2001)
CRS Terra FM1/FM2 Edition 2B



All-sky SW Aerosol Forcing (TOA net - surface net)
Interannual changes as (Mar02-Mar03)



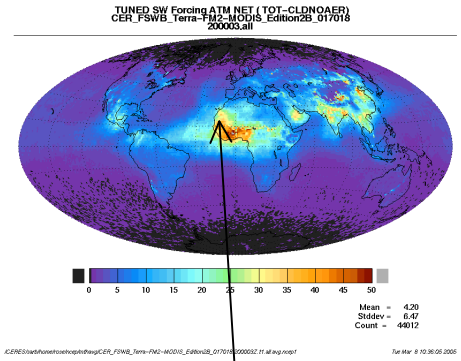
Aerosol single scattering albedo: tough problem. Big change from Ed2A to Ed2B. GISS has photopolarimeter to retrieve ssa… an issue for Coakley's NPOESS meeting

Terra CERES FSW Edition 2B

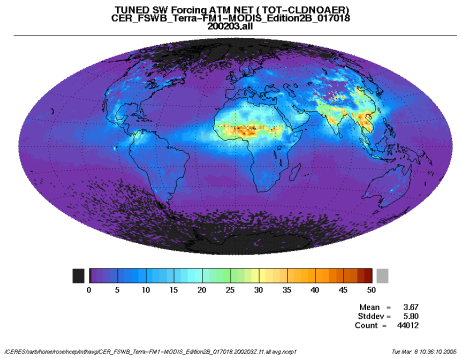
All-sky SW aerosol forcing to atmosphere (day+nite)

(TOA net forcing - Surface net forcing on scale of 0-50 Wm^{-2})

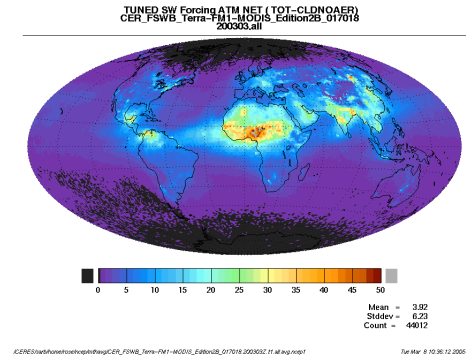
March 2000



March 2002



March 2003



Different winds over Africa in March 2000 pushed the warming dust further NW.

Height of 1000 hPa in gpm (NCEP)